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RESEARCH FOR A HEAD ENCLOSURE FOR AEROSPACE ENVIRONMENTS

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WORCESTER, MASSACHUSETTS

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ALTITUDE PROTECTION BRANCH
PHYSIOLOGY DIVISION
BIOMEDICAL LABORATORY

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FOREWORD

This report was prepared by the David Clark Company Incorporated, Worcester, Massachusetts, under Air Force Contract AF33(616)-8255 "Research For A Head Enclosure For Aerospace Environments". The work was accomplished for the Life Support Systems Laboratory, 6570th Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, and conducted under Project 6301 "Aerospace Systems Personnel Protection", and Task No. 630104, "Space Protective Garments". Mr. Charles R. Kimball was contract monitor for the Life Support Systems Laboratory.

Research activities began on 1 May 1961 and were concluded 3 August 1962. Supervision was by Mr. Joseph A. Ruseckas, photography and illustrations directed by Mr. Richard Murdock, and preparation of copy and editing were by Mrs. Margaret Plante and Mr. Norman H. Osborne of the David Clark Company Incorporated.

ABSTRACT

A comprehensive study was made of possible design and fabrication approaches for a lightweight head enclosure for aerospace environments.

The prototype dome was designed and developed following careful evaluation of the requirements. The transparent hemispherical dome is hinged in the back and is attached to the standard A/P 22S-2 full pressure suit by aluminum locking rings. The convoluted neck joint restraint material is Link-Net of Dacron. The dome is supported by braces resting on the shoulders. An anti-buffeting helmet of lightweight cotton twill houses the energy absorbing pads of Ensolite, the communication system and Straightaway Ear Protectors.

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INTRODUCTION

The physiology of man demands certain minimum standards to insure survival. On Earth, in his natural environment, there are few problems of this type. When man leaves the security of this environment, it becomes necessary to provide one closely resembling that which he left behind. Thus evolved the partial and full pressure suit as we know them today.

With man striving to make progress in the conquest of space, we must provide better and more refined assemblies which will provide complete protection for man in this unusual environment.

The development of the helmet portion of such a protective assembly was undertaken with the idea of designing and developing a lightweight head enclosure for aerospace environments that would integrate with the A/P 22S-2 full pressure suit. The principle of the rigid dome that attaches to the suit at the shoulders and allows freedom of head movement within the dome was selected as the basic design. Such an enclosure appears to be completely practical and has many advantages over the conformal type helmet.

This development program deals primarily with the design, evaluation of the helmet configuration as mounted on a pressure suit and the behavior of the integrated components.

DISCUSSION

Description

The dome is Plexiglas, 14 inches in diameter, hinged in back, with an aluminum base ring. Suit and helmet mating is accomplished through an attaching ring of aluminum and a convoluted neck joint. Free head movement is possible within this enclosure.

The anti-buffeting helmet is made of nylon oxford and houses the Ensolite energy absorbing pads, the AIC/10 communication system (bone conduction microphone and receivers) and the Straight-away Ear Protectors.

No oxygen breathing system design was accomplished, but the ventilating air ducts were extended almost to the base of the dome to provide ventilation in the head area and to provide anti-fogging aid.

The enclosure has been designed to integrate with the A/P 22S-2 High Altitude, Full Pressure, Flying Outfit. (Figures 1, 2, 3, 4, 5 and 6.) The lack of visual clarity in the photographs is due to the protective coating on the dome to prevent scratching during fabrication.

Materials

The dome is a drawn 1/8-inch thick Plex 55 (Plexiglas) as optically correct as possible.

The protective anti-buffeting helmet to be worn inside the dome is made of light cotton twill. The energy absorbing material is Ensolite, 1/2-inch thick, 3-1/2-pound density and held in place with Velcro.



Figure 1

Aerospace Head Enclosure, Pressurized, Front View



Figure 2

Aerospace Head Enclosure, Pressurized, Side View



Figure 3

Aerospace Head Enclosure, Unpressurized, Side View



Figure 4

Aerospace Head Enclosure, Unpressurized, Front View

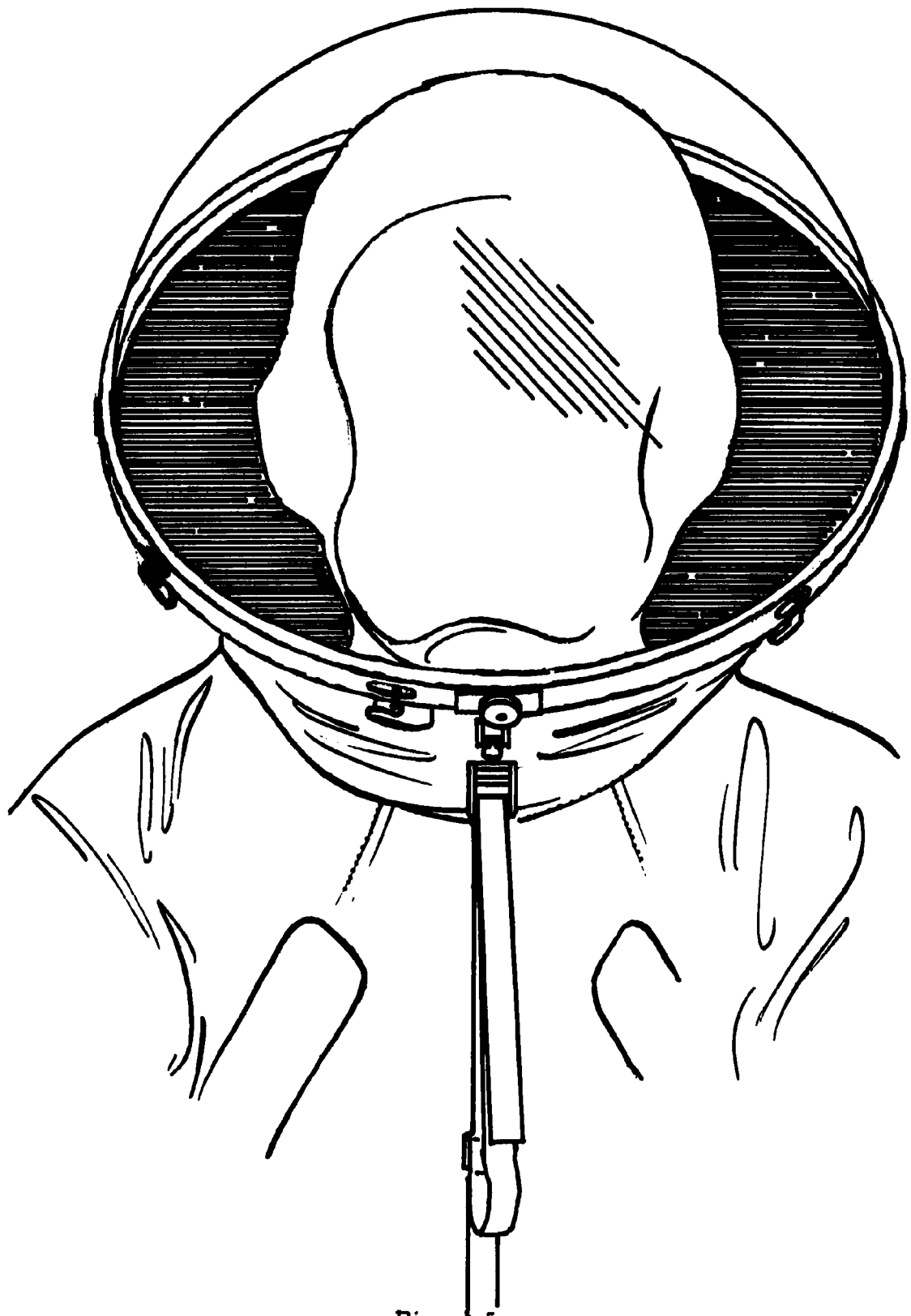


Figure 5
Aerospace Head Enclosure, Front View

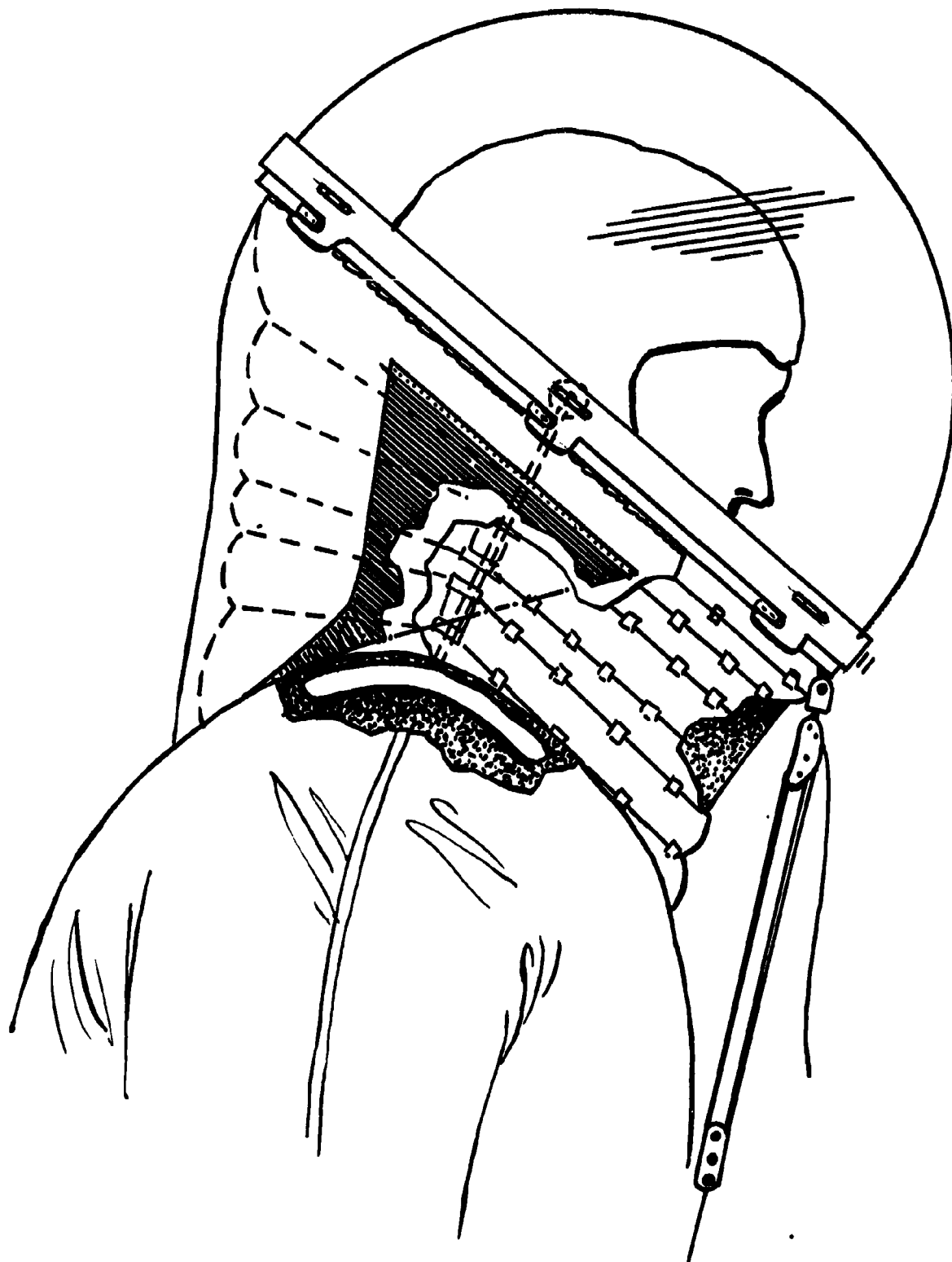


Figure 6
Aerospace Head Enclosure, Side View

Aluminum is used for the locking and attaching rings.

The convoluted neck joint is of neoprene-coated nylon-bladder cloth. Nylon webbing restraint cords are used to hold the convolutes in place.

A high temperature sealing compound WS-215 and Formula 812, #II and #III are used for sealing the Plex 55 to the aluminum ring. Uniformly located screws are used to mechanically attach the dome to the ring. The seal on the connecting ring is of a neoprene compound which is molded in a compression mold.

Ear protection against noise is the Straightaway S/P 2017, shallow dome type (modified to reduce the overall depth). The ear cups are of Cycolac thermal plastic and the seals are vinyl plastic with polyurethane filler.

Hardware such as latches, screws, etc. are of stainless steel.

Dacron cord is used in the Link-Net.

Design Approach

The original approach of a retractable (internal) visor, a bellows-type neck joint with adjustable external links, fiberglass and epoxy resin helmet shell, "O" ring seals (#1) at the helmet/suit attachment point and electrical conductive coating on the visor were investigated and gradually discarded as the dome progressed. All other original points were maintained and developed.

The method of dome support was investigated and we determined that the most practical approach would be to place the supports on the inside edge of the dome beneath the convoluted neck joint. These supports had to be of a design that would allow maximum clearance in the shoulder area for parachute or restraint harness and would not impede donning or doffing of the unit. The comfort factor was also considered to be most important.

The gas tight convoluted neck joint was designed with one end attached to the base of the dome and the other to the suit. This joint allowed shifting of the dome from a 180° position, parallel to the floor, to a 45° forward position while suit was pressurized to 5 psig.

The dome itself was a 14-inch diameter hemisphere of 1/8-inch thick Plexiglas (Plex 55) and drawn as optically correct as possible. Size of the dome was determined by the bulk of equipment anticipated to be worn. This included communications, sound attenuating ear protectors, and the anti-buffet helmet. Every effort was made to keep the overall size as small as possible.

A combination locking and attaching ring fabricated of aluminum was attached to the base of the Plexiglas hemisphere and held in place by a series of screws, equally spaced around the side of the upper ring. A gas tight seal was achieved by injecting a high temperature plastic sealant between the base of the hemisphere and the upper ring.

A second aluminum ring, with a hinge and lock and designed to house the molded rubber "O" ring, was attached to the combination ring.

A clamping ring, held in position by screws, joined the second ring to the convoluted neck joint, locking them together in a gas tight manner.

With these rings and the "O" ring in place, the dome closed and locked to the suit half, 10 psig pressurization was possible without leakage.

The communication system consisted of the anti-buffeting helmet utilizing Type H 143/AIC receivers and a bone conductive microphone (Tissue Speech) which is compatible with the AIC/10 system. The receivers are housed in the Straightaway Ear Protectors, Type S/P 2017 (modified), which were reduced in size to the very minimum in an effort to decrease the overall dome profile. The microphone is embedded in the upper rear half of the anti-buffeting helmet. The main communication cord harness (leads from both the microphone

and receivers) enters the helmet at the base of the left ear cup.

A front adjusting strap attached to the dome rim and the front of the suit controls the attitude of the dome when pressurized. A 4 to 1 ratio load reduction adjustment buckle, plus the mobility acquired from the convoluted neck joint allows the wearer of the suit to adjust dome attitude by pulling the strap, or releasing the catch on the buckle, when pressurized.

Tests and Results

One A/P 22S-2 High Altitude, Full Pressure, Flying Outfit was furnished by Aeronautical Systems Division to the David Clark Company for determination of head enclosure and suit compatibility.

Upon completion of the aerospace dome, the entire assembly was subject tested (unpressurized) for ease in donning, comfort, visibility, head mobility and compatibility.

It was determined that the air supply channels would have to be extended to the top of the convoluted neck joint.

The dome in the unpressurized condition has a tendency to tip forward by virtue of its own weight. Adjustment straps emanating from the center back of the suit and attached to the side pivotal points of the dome were installed which corrected the condition. The subject has only to make one adjustment in the unpressurized condition and the dome subsequently remains in proper relationship in all areas.

The suit and dome (unoccupied) were then pressurized to 2 psig which was the maximum pressure attainable because of yielding of the aluminum ring at the dome base. This was caused because the back hinge and front pivot lock were the only locking points between the top and bottom dome base rings. This left the sides unsupported, resulting in moderate deflection of the ring when pressurized and, consequently, loss of seal usefulness. This condition was corrected by fabricating a ring with bayonet-type connectors added,

which was attached to the lower ring of the dome base. These connectors mated with lugs spaced 2 inches apart around the circumference of the upper ring, thus alleviating this ring weakness. The "O" ring (#1) was eliminated and a combination lip and compression seal (#2) was installed, which would eliminate possibility of future leaking (within the travel limits of the seal) should any slight ring deflection occur.

Seal #3, using a combination compression wedge seal, was attached to the dome clamping ring, which in turn was mounted to the test fixture. The unit was gradually pressurized from 0 - 10 psig. Peak pressure was maintained for approximately 10 minutes, at which time it was deemed structurally sound, as per contract profile. However, at lower pressures, excessive leakage through the seal was noticeable.

Modification of the seal mold was required to eliminate this problem. The forward, inner edge of the mold was increased in dimension to create a more positive wedging action, which resulted in an adequate seal at lower pressure.

The dome with the modified seal installed was then removed from the stress test jig and attached to the suit. Leverage to overcome the wedge seal and close the dome was far greater than anticipated and another seal (#4) of a softer consistency was fabricated.

With the soft seal installed, the unit closed but the effort required was too great. However, with these conditions prevailing, the suit was pressurized to 5 psig, with a slight leak at 4 psig, due to a defect within the seal. Reduction of incline on the locking lugs of bayonet fitting, to reduce torque of closing and assembly was then tried. This was unsuccessful and a definite increase in leakage occurred due to the extra tolerance in gapping allowed with this change.

During the preceding test, the neck joint attitude strap yielded a 5 psig and a redesign was necessary to overcome the problem. The fabric attachment was doubled in ply and two straps (nylon webbing) were added to distribute force over a greater area.

A lip seal (#5) of the original design configuration, was re-studied, and added to the dome. With the use of the bayonet fitting, the yield in the clamping ring became minimal. The success of this seal was considered to be the final configuration.

Discussion of Results

The final Aerospace Head Enclosure configuration has several distinct features which are advantageous to the wearer.

1. The overall field of vision (with the head held in a fixed position within the dome) is restricted only by eye movement limitations.
2. The plastic dome has been fabricated as closely to MIL-V-27446 specifications as possible and the optical qualities in the critical visual area appears to be acceptable for precise visual requirements.
3. The oro-nasal area is easily accessible by dropping the front lower portion of the dome.
4. Pressure points on the head will be non-existent because the dome is well supported from the shoulder areas.
5. Universal sizing of the dome is possible without intricate lacings, crown pads, etc. Anti-buffeting helmet sizing is comparatively simple.
6. Weight is at a minimum because the rigid dome principle does not require a rotating bearing or adjustment harness.
7. Anti-fogging capabilities appear to be reasonable as the ventilation air has been directed toward the critical visual area.

APPENDIX I

SEALING COMPOUND AND METHOD OF APPLICATION FOR THE AEROSPACE ENVIRONMENTAL HEAD ENCLOSURE

PRODUCT DEVELOPMENTS DATA SHEET

SUBJECT:	Sealing Compound And Method	Report No. R-1008
	Of Application For Aerospace	Paper No. Pg 635 #5
	Environment Head Enclosure	Pg 730 #6
		Date: 6/15/62

1. Scope:

- 1.1 To design and develop sealing compounds and method of attaching Plex 55 (Acrylic Plastic Dome) to aluminum (2124-14) ring.
- 1.2 The integration of the above items (parts) with each other and the full pressure suit is to be accomplished in the manner which will minimize bulk, weight, and leak rate, as per Exhibit WWRDLP 61-19 dated November 1960 to AF33(616)-8255.

2. Materials:

- 2.1 Plex 55 Dome
- 2.2 Aluminum Ring
- 2.3 WS-215 Sealing Compound - Silicone Elastomeric Compound
- 2.4 Formula 812 #II - Epoxy Soft
- 2.5 Formula 812 #III - Epoxy Hard
- 2.6 Hypodermic Needle

3. Procedure:

- 3.1 WS-215 was cut (five or six pieces) 1/4-inch wide and 1/8-inch thick. The strips were inserted evenly in the bottom of the aluminum ring (2.2).

- 3.2 Centralizing, the dome was pressed down firmly into the ring insert, displacing approximately 1/16 of WS-215 (2.3) which acted as shock resistant padding and prime sealing compound.
- 3.3 Specially developed soft Epoxy compound formula 812 II (2.4) with the aid of a hypodermic needle was then filled on both sides of the dome (Plex 55) up to insert 1/16 inch deep and 1/32 radii. This was cured for 24 hours at room temperature.
- 3.4 After completion of terminated cure, formula 812 III Epoxy compound (red); which is applied again with the aid of the hypodermic needle, was filled on both sides of the dome (Plex 55) to the top of the insert and this was also allowed to cure for 24 hours at room temperature.
- 3.5 After the sealing compounds were completely cured, holes were drilled through the dome (Plex 55) for "Seal Screws".

4. Conclusion:

Based on preliminary evaluation data, and practical results obtained, the compounds and method of construction used as described in this report should comply with standard cold -60°F and hot 160°F environments as well as other requirements set forth in Exhibit WWRDLF 61-19 dated November 1960 to AF33(616)-8255.

Sample prepared and assembled by:

Sharon MacLean

Approved by:

[Signature]

APPENDIX II

MOLDED RUBBER SEALS AND METHOD OF APPLICATION FOR THE AEROSPACE ENVIRONMENTAL HEAD ENCLOSURE

PRODUCT DEVELOPMENTS DATA SHEET

SUBJECT: Molded Rubber Seals And
Method Of Application For
Aerospace Environmental
Head Enclosure

Report No. R-1010
Paper No. 723 #6
Date: 7/28/62

1. Scope

- 1.1 To develop a static seal rubber compound which would provide necessary physical properties without degradation in anticipated environment.
- 1.2 Develop method of attaching molded seal to the Dome clamping ring.

2. Materials

- 2.1 Stock K-1235 Silicone Rubber O. D.
- 2.2 Stock WS-214 Silicone Rubber (yellow)
- 2.3 Stock 3N2A (ACS-218) Neoprene Latex
- 2.4 1/4-inch Polyurethane Foam
- 2.5 Neoprene Adhesive

3. Test Procedure and Results:

- 3.1 First approach to the problem was to fabricate a static seal which consisted of 2.3 and 2.4 compounds as illustrated in Figure 7 - (A).

After installation of the above seal, the test results showed that the design was capable of sealing; however, due to internal high pressure and extreme softness of the material, the upper edge (uncemented) was forced to roll out, causing noticeable leakage.

- 3.2 As a result of the above findings, a new seal was designed (stock 2. 1) integrating with the same Dome clamping ring.

This seal offered a number of advantages, such as superior physical properties, and inexpensive fabrication as well as high environmental resistance; however, in order to obtain good sealing performance, more compression between clamping rings was essential. See Figure 7 - (B).

- 3.3 Stock 2.2 was designed to fabricate (mold) seal as described in paragraph 3.2; which was 30% softer and with larger sealing surface. See Figure 7 - (C).

This seal performed very well even at low pressure, but because of modification requirements of closing mechanism it was felt that less bulky seal would be the immediate answer.

- 3.4 To further modify and redesign the mold or the mechanism was impractical at this point because of the time. Consequently, the seal fabricated as described in paragraph 3.1 was modified as illustrated in Figure 7 - (D). As a result, installing and partially cementing urethane foam to the sealing surface not only eliminated rolling out of the film, but also produced an effective seal and reduced the closing compression. All of this was achieved with success.

Sample prepared and tested by:

Clifford Albrecht
Sharon MacLean

Approved by:

[Signature]

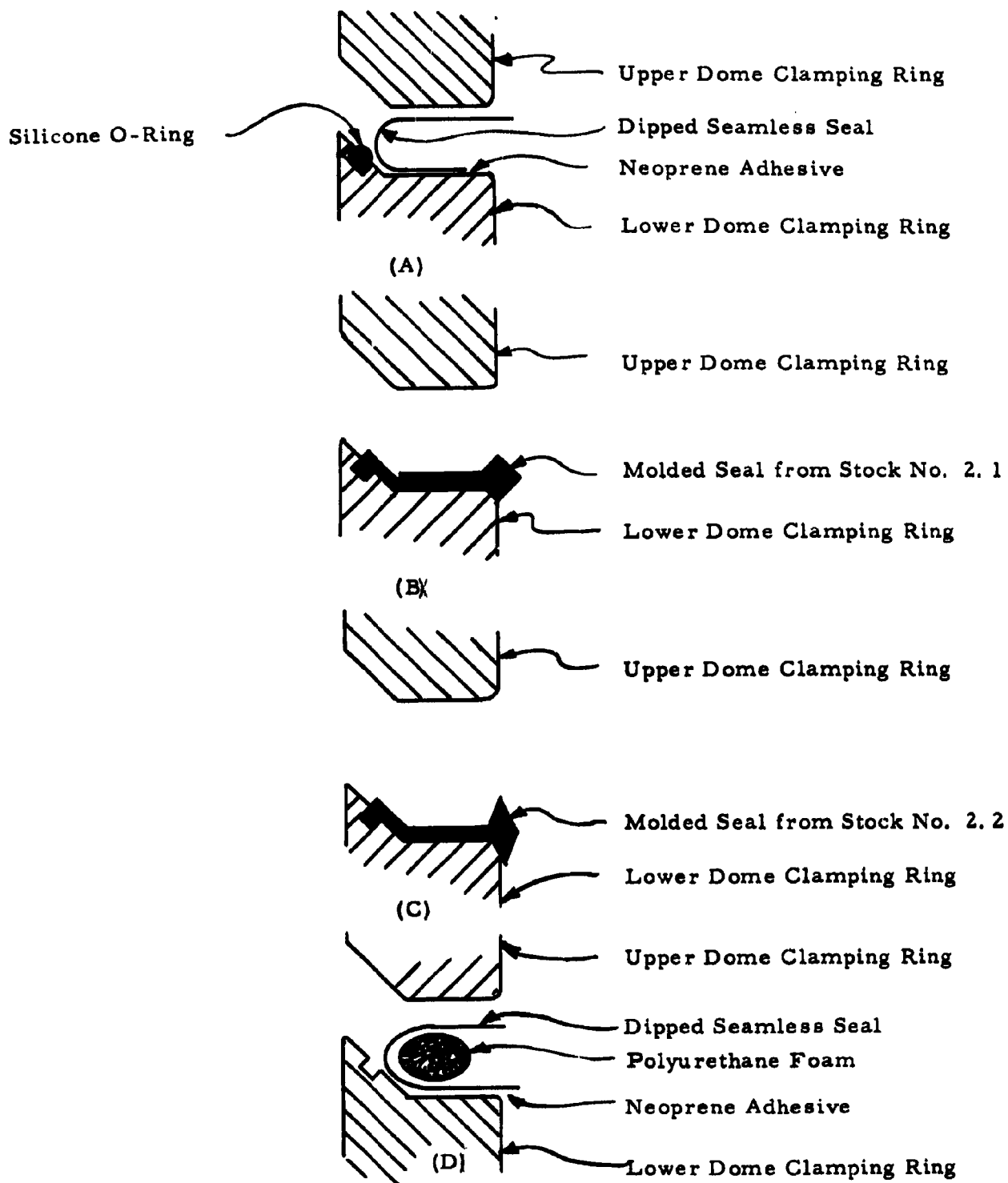


Figure 7
Tentative Aspects of Seal Design